JEAN ROTZ: HIS NEGLECTED TREATISE ON NAUTICAL SCIENCE

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THE men of science of the sixteenth century were peculiarly unfortunate in that their theory outstripped their practice, largely owing to their inability to make precise measurements. Failing a timepiece that was even tolerably accurate, the chronometric method of finding the longitude as outlined by Gemma Frisius* in 1530 necessarily remained untried: while without a vernier, or even a diagonal scale (for Nonnius' device was scarcely applied) angular measurements could be made only to about 10′, save on quadrants so huge as to be impracticable in normal circumstances. The result was that astronomical methods for fixing position were at a discount. The practical man, indeed, was not entirely without justification in concluding that he got on better by rule of thumb.

Nevertheless, both Spain and Portugal had their well-established Schools of Nautical Science: the middle of the century saw the brief but brilliant career of Richard Chancellor, seaman and mathematician; while buried in the Royal Library of England were the works of Jean Rotz, of Dieppe, hydrographer, instrument maker, student of marine astronomy, and experienced sailor. One of his manuscripts, hitherto apparently unnoticed, forms the subject of the present study.

The cartographical work of Jean Rotz is typical of the French school of the fourth and fifth decades of the sixteenth century (e.g. Desceliers, Vallard); nor is his treatise on Nautical Science † unique, save in its survival. Pierre Crignon, the poet-navigator of Dieppe, had written his 'Perle de Cosmographie' in 1534, and from Delisle's note ('Histoire de l'Academie Royale des Sciences,' 1714), its subject-matter, in part at least, was navigation. Jean Rotz, however, is here singled out for notice because he placed his knowledge at the disposal of Henry VIII, who, by failing to allow the publication of this treatise (and of that of Roger Barlow, written two years earlier), let slip the opportunity for providing that instruction in nautical science for which Hakluyt was still vainly pressing at the end of the century.

Jean Rotz' manuscript, written in French, is sometimes difficult to decipher. The title runs: 'Treatise on the variation of the magnetic compass and of certain notable errors of navigation hitherto unknown, very useful and necessary to all pilots and mariners. Composed by Jan Rotz, native of Dieppe, in the year 1542.'

In a long and flattering preface to the King, the writer says that he comes before him not empty-handed, but bearing a book and an instrument for his acceptance: the book composed for all those who wish to taste the pleasant fruits of Astrology and Marine Science. It is not written, he adds, in the common tongue of the (English) people, although the author, having spent part of his life in England, has some knowledge of the language, but he knows the King's love of the French tongue, while his Grace may, besides, choose whether to keep the book for himself and so be the superior of his subjects in science, or whether to have it translated for the instruction of his mariners.

*Gemma Frisius, 'De Principio Astronomiae et Cosmographiae.' 1530.

†Royal MSS., 20 B VII, p. 303.

"Laquelle seroit cause comme j'estime qu'on trouveroyt en pou de temps autant ou plus de bons et parfaictz pillottes et astrologues de marine en Angleterre quen aultre lieu du monde." Rotz excuses himself for not presenting also a nautical chart, but does not doubt that the king has already received examples as fine as any he has made or will make. Further, he begs his Grace not to notice the workmanship of the Instrument, since it is the first of its kind to be made.

The book itself is divided into three parts, of which the first treats of the spherical shape of the Earth, with emphasis on the proof by experience on long voyages. The second part deals with the imperfection of the marine chart and its causes: ". . . la maniere et facon du compas aymante, la difference du regard de son north (*sic*) envers le pole, et la plus commune oppinion sur ce tenue, avec la premiere maniere et facon de la carte marine, emoins par les modernes, observee; et par consequent de la difficulte et faulte de ladicte carte procedant de ladicte difference de regard du north du compas envers le pole."

The third part treats of the construction and use of the instrument, which the inventor calls a Differential Quadrant (see Plate). Actually it is one of the precursors of the theodolite, and a very elaborate one. The large magnetic compass set in the horizontal circle suggests a marine origin, and it may be compared with the contemporary instruments designed for taking horizontal bearings by such landsmen as the brothers Arsenius, which were orientated by tiny compasses inset on the margin. Like Waldseemuller's Polymetrum,* Rotz' instrument could take a combined altitude and azimuth, but its prime purpose was for the accurate determination of the variation of the compass. Thus the title of Part III runs: "La composition et usaige de linstrument que nous avons praticque pour lobservation des differences du compas declarez en la precedente partie. Et la maniere de prendre toutes latitudes et eslevations polaires. Avec la maniere et usaige de praticquer la longitude par la lune et une etoile fixe selon la doctrine des cosmographes. Et aussi lusage pour scavoir les heures egalles du jour artificiel en toutes regions et finablement une brefve doctrine pour prendre toutes longitudes, latitudes et profunditez de geometrie par la moyen dung Instrument."

The making and assembling of the instrument are described with great care, separate working drawings being given of each part. These reveal that the general sketch given in the figure is faulty in some important respects, notably as regards the fitting of the vertical and horizontal circles. Actually the horizontal part of the instrument is in three concentric sections. The innermost is the mariners' compass, the needle very delicately poised, and protected by a sheet of glass. This box compass carries an alidade, the fiducial line corresponding with the N.—S. line on the compass rose, and extending across the angular graduations on the second section, the mobile circle. It is into this latter that what Rotz calls the orthogonal circle is mortised, so that it can be rotated into any desired position. The outermost base circle is rigid.

The vertical portion is also threefold: the outer and rigid graduated circle embraces a mobile circle carrying sights. These are joined by a thread (fil)

*Compare also *G.J.*, 72, No. 4, p. 329.

representing the axis of the Earth. The mobile circle carries a ring in a third plane which is graduated to serve as an ecquinoctial or universal dial. An important feature not shown in the drawing reproduced was the levelling device. This consisted of three metal knobs screwed at equal distances into the rigid base: by twisting these knobs farther in or out the base could be levelled with the help of a plummet. A suspensory ring was provided for use at sea, and the inventor points out that to avoid the instrument's swaying in the wind the base must be weighted with lead at discretion.

Like Pierre Crignon and some other intelligent men of his day, Jean Rotz believed that he should find in the variation of the compass a solution of the problem of longitude. Reasoning from insufficient data, his conclusion was faulty, but none the less interesting. The facts he set out are these: he knew that the deviation at his native town Dieppe was 10° E., while he had himself determined a deviation of 8° E. in Guinea, and 10° W. in Brazil; and he learned from those who frequented the navigation to Terre Neufve (Newfoundland and Canada) that there it was as much as "half a run of the wind," or 22½° W. He records further that two ships of Dieppe, sailing to "Trapobane," *i.e.* Sumatra, found the deviation there to be 35½° E. He is uncertain, however, whether there was a steady increase to this value throughout the voyage, or whether the deviation had not passed through a maximum and was decreasing, since the distance in longitude traversed exceeded a quarter of the circumference of the world by 35°, *i.e.* Taprobane lay 125° E. of Ferro. The reference is undoubtedly to the voyage of 1529 to Sumatra made by the Parmentier brothers of Dieppe, on which Pierre Crignon accompanied them, and the deviation of 35½° E. and the longitude 125° E. (less than 8° out) are some of the data upon which Pierre Crignon must have based his theory of longitude: his work was evidently known to Rotz.

The latter's revelation of travel, too, is interesting. It is the Guinea–Brazil route he knows, returning by the Azores: he gives the date of one Brazil voyage, the autumn of 1539, while he also mentions being at sea in 1529. This is just the period of the English Brazil voyages, and as Rotz mentions his residence in England, he may have been employed as pilot by the elder Hawkins or his confrères.*

To return, however, to the observations. Leaving aside the Taprobane figure, Rotz compared the other deviations with the linear (not angular) distances from the prime meridian, on which, so he stated, the deviation was nil. Thus Cap Raz was 480 leagues W. and the deviation there 22½° W.; this gives a deviation of 1° for every 21¼ leagues. The other observations gave varying values up to 24 leagues, but the differences were put down to errors of the charts from which the distances were taken, and 21¼ was accepted.

It is clear from his diagrams that Rotz considered that the needle, wherever it was carried, remained parallel to itself, and to a plane drawn through the prime meridian. Hence if it was taken west, the convergence of the meridians would produce an (apparent) deviation to the west, and similarly, if it were carried to the east, a deviation to the east. At 90° E. or W. the deviation would pass through a maximum, hence the rejection of the Sumatra figure. Sebastian Cabot appears to have had a somewhat similar theory, although he placed his zero line west of the Azores.

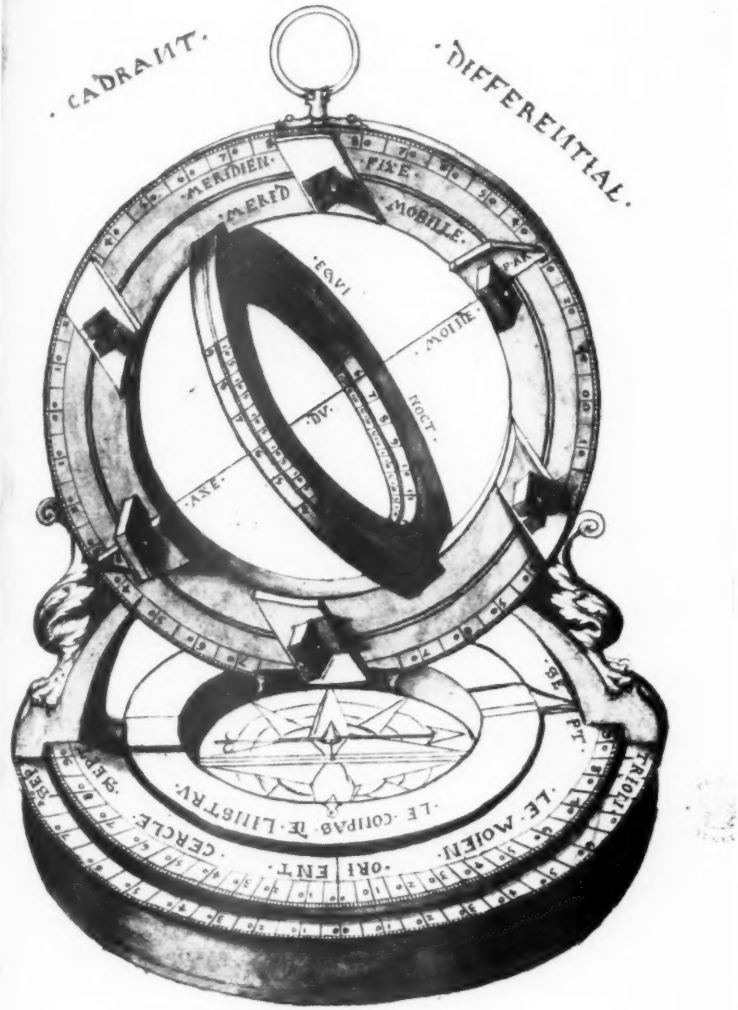
*J. A. Williamson, 'John Hawkins,' ch. i.

That Jean Rotz, even when at fault, was ahead of his contemporaries is clear when we compare his work with the extremely popular Spanish Navigating Manuals of Pedro de Medina (1545) and Martin Cortez (1551). Pedro de Medina, an experienced West Indian pilot, held that the "north-westing and north-easting of the needle" (as it was called) was of little moment, and was associated with the movement of the Pole Star round the pole. He remarks also that since the "virtue" of the compass resides in the needle and not in the rose (i.e. card), it is to be regretted that compass makers do not make the north point of the needle tally with that on the card. This emphasizes a further cause of confusion on which Jean Rotz also dwells. Just as the compass-clock makers of the fifteenth century cut the magnetic deviation on the dial as a matter of course, so the marine compass-makers allowed for it, and as the rose or card was attached *above* the needle, and adjusted so that the north point or "lilly" pointed to the north star, the deviation was not brought to the pilot's notice. Sailing, too, was only to 32 points, and consequently any small variation was likely to escape notice or be dismissed as accidental, *e.g.* the variation as between Dieppe where the deviation was 10°, and London where (according to Digges in 1571) it was $11\frac{1}{4}°$, or just one point east of north.

As and when, however, navigation became more cosmopolitan, a new difficulty was introduced: a compass made in one port, with the local deviation allowed for, did not tally with a compass made in another port, when both were taken overseas. Columbus, for example, refers to the readings of his Genoese and Flemish needles respectively on his Second Voyage. On this point Rotz furnishes interesting details. The Portuguese, for the navigation to Guinea, made compasses corrected for a deviation north and quarter north-east. The Italians, for the Mediterranean navigation, made no correction. The French, Scots, English, and Flemings made needles practically alike, corrected for a deviation north and half a quarter north-east. For transoceanic voyages the French compasses were very variously corrected, and Rotz considered that all such methods were at fault, for since there was a continuous variation from point to point, the only method of determining the true direction of the ship's course was to make frequent comparison between the geographical and magnetic meridians. As exemplifying the errors of current practice, he states that it was the usual experience on the return from Brazil for the master to find himself 70 leagues farther west of the Azores than his reckoning showed, notwithstanding the exactness with which both Brazil and these islands were, so he says, laid down on the charts, as a result of being frequented by people of many countries. Such errors were put down to currents and faulty seamanship, but were due to faults of the compass.

Rotz reiterates that the variation of the compass and the sphericity of the Earth alike determine that the rhumb lines, forming a parallel network, in the marine chart, do not represent true bearings. Hence errors arise in using the charts, and it is very necessary that positions should be fixed astronomically, although he recognizes that not only are the operations difficult in themselves, but the computation requires more knowledge of astronomy than the ordinary ship-master can command.

He gives two supposititious examples of longitude determination, as



The "Differential Quadrant" of Jean Rotz: from the manuscript in the British Museum

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follows: "je dycts que le 15e de Janvier 1529, moy estant dessus la mer voulus scavoir la distance de mon meridien au meridien dulme." At sunrise, then, which occurred at 8 o'clock, he took his astronomer's staff "dict par les mariners esbalester" and measured the distance between the sun and moon, finding it 41°. Two folios of complicated calculations follow, and finally, taking Ulm to be in 47° N., 30° 20′ E., the required longitude is found to be 180° E. of Ferro, *i.e.* somewhere east of the Moluccas. Using in the second example the moon and a fixed star, he says, "Moi estant sur la mer veulant scavoir la distance de mon meridien de Dieppe, premierement je rectifies mes ephemerides ou tables dalphonse au meridien de dieppe et puis je regard le vrai lieu de la lune pour ung certaine heure de la nuyt," namely ten o'clock, when he finds it 16° in Taurus, and determines its declination. He also finds the right ascension of the star Aldebaran "aprez toutes rectifications faictes destiez" 2° 18′ in Gemini, and its declination 15° 55′ N. "Et notte ycy ung poinct cest quil est necessite que tu rectifies ton heure par en moyen des equations des heures mis aux tables dalphonse ou aux ephemerides." Again, a couple of folios are occupied by computations, and the longitude works out as 229° 30′ E., or somewhere in mid-Pacific. Rotz does not, unfortunately, give any examples of the observations he would make for determining the variation of the compass, although it was for this his instrument was specially designed.

It appears, from several direct references, that Jean Rotz was a student of the deservedly popular writings of Peter Apian, and especially his cosmography. It is not surprising, therefore, that in the last section of his book he refers to the method of map-making by triangulation, due to Gemma Frisius, and found in his editions of Apian from 1533 onwards. The title of chapter 8 runs: "De la mensuration pour practicquer les longitudes et quantitez des espaces qui seront enter tous les lieux a lenviron de toy, et desquels tu veulx avoir lesdits espaces et mensurations, voyre pour lieu que tu les puisses veoir, et ce par angles sans calcul et par deux stations seulement."

After describing the method and drawing the diagram as in Frisius-Apian (although without reference to particular places), Rotz adds, "Et davantage tu doits scavoir que ceste maniere de faire seroit tres necessaire et utille pour la composicion de quelque carte terrestre, tant pour la scituation de tous les lieux, places villages, chasteaux, et villes et citez que lon voudroit escrivre en icelle selon la latitudes par lesquels seroient trouvez les unes et les autres."

This Dieppe seaman had no reason to complain of his personal reward at the King's hands. He was taken into the royal service, and described himself as "servant of the King" in the Boke of Ydrography (written in English), the preparation of which was his first official duty. At Michaelmas in 1542, he received a payment of £20, being one-half of an annuity of £40, then a very considerable sum,* while on October 7 of the same year† he was granted papers of denization for himself, his wife and children. Here he is described as "native of Paris," and as he speaks incidentally of having given two years to the study of nautical problems, he may have retired to that city from Dieppe in 1540.

*Letters and papers of Henry VIII, vol. 17, g. 880, fol. 426.
†*Loc. cit.*, Appendix A, 20.